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Piezoelectric power harvesting from chirps and mating swiftlets attraction sound

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Abstract

The voltage measurement from piezoelectric disk (PZT) transducer is proposed in this paper. The attraction sound that has been used in the swiftlet farming industries was emitted at three different levels. The PZT was placed inside and outside the speaker to identify maximum power to produced high impulse voltage. The swiftlets sound was recorded using Avisoft software and analysed in Matlab. The sound was dividing into seven frames and it spectrum was plotted using Fast Fourier Transform (FFT) function to acquire the magnitude and frequency information. A Strip chart used to log and graph values acquired from PZT for 100 Hz sampling rate. The impulse response for each sample was saving in excel format and analysed in Matlab software. The finding showed, the voltage acquire from different type of swiftlets sound is significant different. In addition, the voltage generated from two PZT location also showed significant different. The reason can be highlight here is voltage generated by PZT is depending on the power of sound transmitted. The higher power sound transmitted the higher voltage generated from PZT.

Key words: *Piezoelectric, Power harvesting, Swiftlets sound, Voltage impulse response*

1. Introduction

The demand for electricity is increasing from year to year. This led to rising demand for fossil fuels as fuel in electric power stations. It is important to ensure that the electricity generated is sufficient. However, world oil prices that rising high and unstable indeed be a burden to the public because they have a significant impact on the cost of electricity generation. The use of renewable resources is seen as a new source to replace the existing energy sources. The study found that there are four high-potential energy sources to be developed in the power generation sector. The energy is solar energy, wind energy, hydropower and nuclear energy (Anderson *et al*., 1993).

Hydro and nuclear power is a popular source that has been used in some developed countries because it can generate a lot of electrical energy. However, it gives negative impact on the environment. For example the construction of a hydro dam will affect ecosystems, including wildlife, plant diversity, people and the local economy. The construction of dams will lead to decreasing rainwater catchment areas, wildlife and destroyed the organism.

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In addition, the hydro flow has changed dramatically, the chemical and physical properties and water quality also changed. For nuclear energy, the radioactive materials waste from the power plant activities are very dangerous and not capable of being used by some countries.

One of the new energy promises is through the conversion of vibrations into electrical energy through a piezoelectric (PZT) device. This energy can be stored and used to power up electrical and electronics devices (Dayou *et al*., 2009). The PZT is a ceramic material, discovered in 1880 by Pierre and Jacques Curie. They studied on the generation of electrical charge by crystals such as Quartz, tourmaline, and Rochelle salt. The term piezoelectricity was first introduced by W. Hankel based on the thermodynamics principles (Jordan and Ounaies, 2001).

The PZT technology has been widely applied in many applications, for example it has been used to convert stress from vehicle. The transducer is embedded beneath the road and will convert energy while vehicle pass them (Abbasi, 2013). In addition, PZT has been design as micro electromechanical systems which supplies energy to the wireless sensor network (Nechibvute *et al*., 2012). The application of PZT as a power harvesting can be used to supply daily low power electrical appliances such as sensor, battery charger, power bank and so on.

The power conversion using PZT is very wide and expended to convert sound wave to electrical power, for example energy also can convert from aircraft noise such as aerodynamic noise, engine and other mechanical noise (Gupta *et al*., 2013).The comparison vibration from three source which is construction pilling, hydraulic pump and train wheel discovered that vibration from train wheel give high voltage for distance 2 until 10 inches (Ahmad *et al*., 2014).

Scientists described sound through some parameter which is amplitude, intensity, cycle and frequency. Human with good hearing can hear sounds from 20 to 20 kHz, but the best human hearing is around 3000 to 4000 Hz, where speech is centered (Scowcroft *et al*., 2012). The sound frequency spectrum is divided into three ranges, which are infrasonic, audio range and ultrasonic. The sound range for human is located in audio range in the sound spectrum. The sound below 20 Hz is called the infrasonic range and above 20 kHz is the ultrasonic range. Sounds are extensively used in various fields especially in the field of engineering and technology.

Sound is categorizing a physical wave that produces a pressure to medium (air or water). The pressure of sound then can be converting to electrical energy through PZT device. The swiftlets sound emitted from bird house is one of the resources can be used as an energy conversion. The swiftlet farming industry in Malaysia only started to gather momentum after the Asian Economic Crisis of 1997–1998. Generally, people who involved in that business need to provide place for swiftlet to produce nest. Currently, the business of swiftlet farming essentially involves the construction and conversion of people-centric buildings into bird house (Merican, 2007).

Currently there are 24 species of swiftlets recorded in the world. Most malaysian species of swiftlets are superficially alike and are difficult to identify. In Malaysia, there are seven species of swiftlet recorded which is *Collocalia esculenta, Collocalia gigas, Collocalia francica, Collocalia vestita, Collocalia brevirostris, Collocalia fuciphaga, Collocalia maxima* (Smythies, 1960). Aerodramus Fuciphagus is a particular species of switlet that produces edible nest, only available in the Southeast Asia region. It consists of 90–95% of edible nest and 5–10% of feather and purities (Ibrahim *et al*., 2009).

The previous research state that swiftlets hearing responses is in frequency range from 1–16 kHz and which most energy on 2–5 kHz (Coles *et al*., 1987; Fullard *et al*., 1993; Nurzalikha *et al*., 2013). The house for swiftlets farming basically developed and equipped with recorded sound of chirping and mating from natural habitat (cave) to attract swiftlets to enter the building (Nurzalikha *et al*., 2013).

Usually, the attraction sound from swiftlets farming industries emitted for a period of time to attract wild swiftlets come to bird house for mating and nesting. A swiftlet produce special sound properties especially for chirps and mating. There two method to place the speaker which is internal and external. Basically, the location of external speaker is on the roof house and the internal located at wall swiftlet house as shown in Figure 1.

The continuous vocalization of swiftlet sounds (chirps and mating) played daily using audio amplifier systems and speakers installed will attract

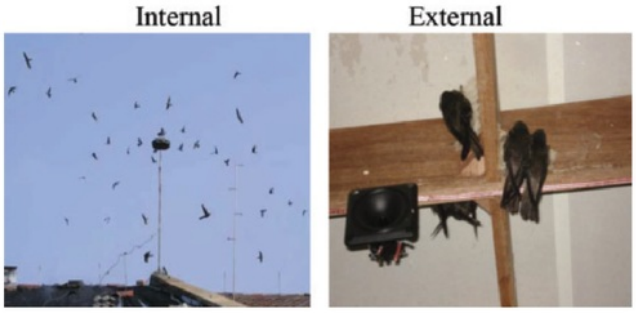

Fig. 1. Internal and external speaker attach at the Swiftles House.

swiftlets to build their nests and mate in the buildings (Lim, 2007). The conversion from sound to electrical energy by PZT is limited finding. Therefore, the research must be conduct to collect scientific information on the effect of swiftlet sound towards piezoelectric sensor. The sound properties such as magnitude and frequency should be investigated to ensure how it can affects the impulse response generated by piezoelectric.

2. Methodology

The swiftlets sound was emitted using rectangular horn speaker with dimension 0.255 m x 0.18 m. The chirps and mating swiftlets sound used in this study is from original sound that has been used by swiftlets farming industries. The sound was emitted for 35 seconds at different power level by tuning the power amplifier. The swiftlets sound has been recorded and edited using Avisoft sound recorder. The condenser microphone was placed at the horn speaker face to record swiftlets sound. The PZT transducer with diameter 27 mm has been used to convert the sound pressure into electrical energy as shown in the Figure 2.

The sensor stand holder has been design to ensure the PZT transducer perpendicular to the horn speaker face as presented in Figure 3. In addition, this stand holder also can facilitate the measurement at different distance. The PZT

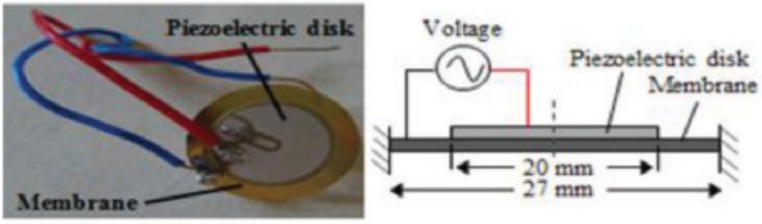

Fig. 2. Piezoelectric transducer.

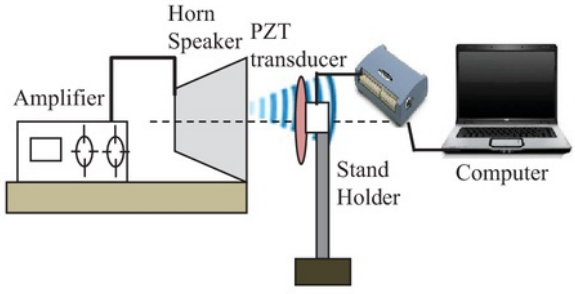

Fig. 3. The instrument arrangement in the experiment.

transducer has been placed at face and inside the horn speaker. The voltage generated at this two point was compared to identify maximum impulse response produce by PZT.

The PZT transducer was connected to analog digital converter (Measurement Computing - USB1208HS). The sample of impulse response voltage produced by PZT was read in strip chart graph using TracerDAQ software. Strip chart used to log and graph values acquired from analog input. The impulse response for each sample was saving in excel format and analysed in Matlab software.

3. Result and discussion

The sound signal emitted from speaker was recorded using Avisoft software and data saving in wav format for 35 seconds. The swiftlets sound was emitted in three difference level namely type A, type B and type C. The sound types have same frequency but different magnitude as shown in Figure 4. The signal analyzed in time and frequency domain using Matlab software. The data has been collected for 10 samples for each type of signal.

The impulse voltage produced by PZT was sample at 100 Hz and then analysed in matlab software. The signal comparison between two locations of PZT at the horn speaker showed that more voltage generated if PZT place in the speaker. The sound was cut into seven frames to observe the signal pattern contain in swiftlets sound. The Fast Fourier Transform (FFT) function was applied to acquire magnitude and frequency information. Figure 5 demonstrated example of swiftlets sound at different time frame.

The analysis of sound at different frame for 35 seconds demonstrated that the frequency range of

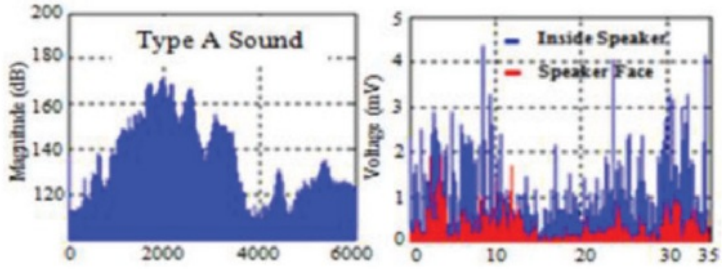

Fig. 4(a). Type A sound frequency spectrum and voltage response from PZT.

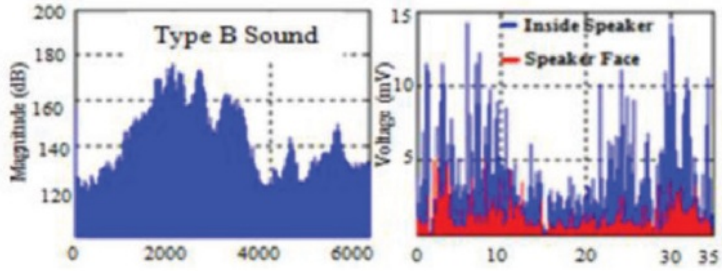

Fig. 4(b). Type B sound frequency spectrum and voltage response from PZT.

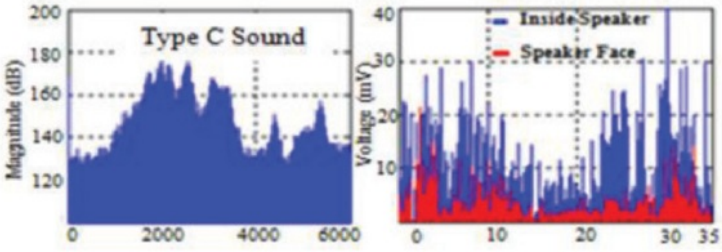

Fig. 4(c). Type C sound frequency spectrum and voltage response from PZT.

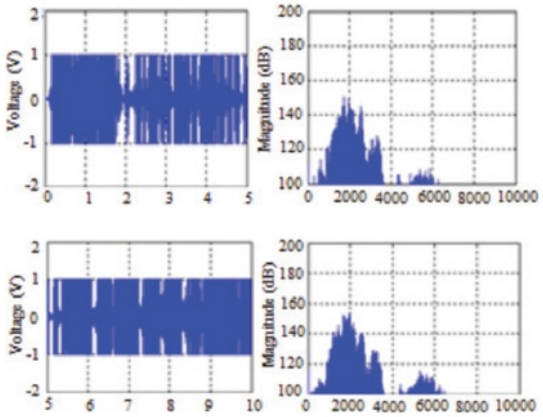

Fig. 5(a). Swiftlets sound from 0–10 seconds and power spectrum.

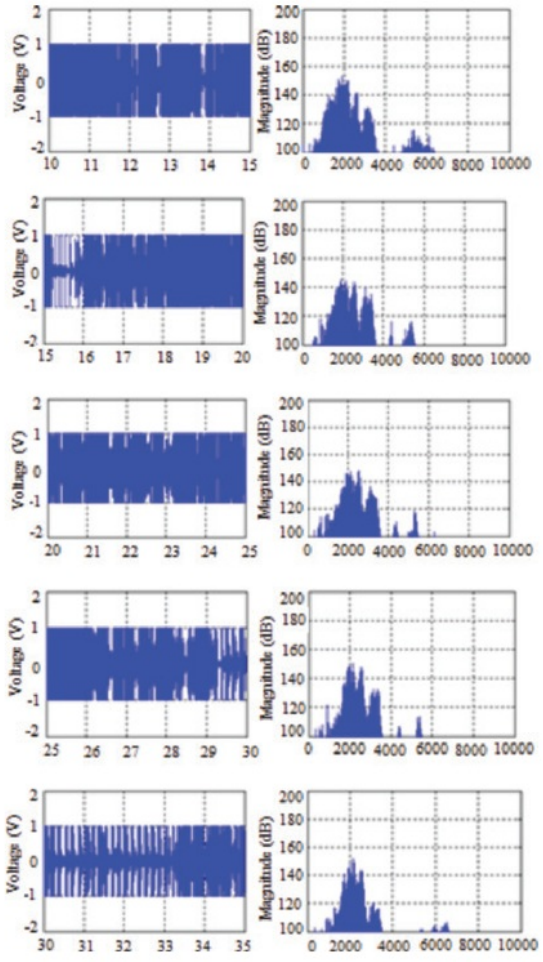

Fig. 5(b). Swiftlets sound from 10–35 seconds and power spectrum.

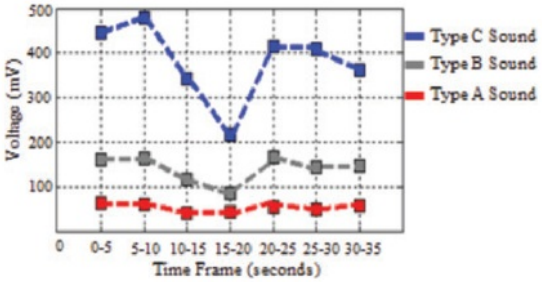

Fig. 6(a). The voltage generated from PZT in the horn speaker.

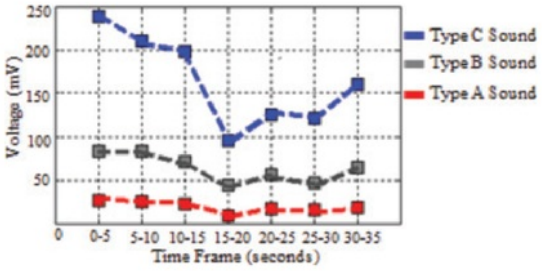

Fig. 6(b). The voltage generated from PZT at the speaker face.

swiftlets sound is between 0.3–6.6 kHz. The signal contain more swiftlets sound have wide frequency range. The three type sound with different level has been emitted using horn speaker and the voltage generated from PZT was plotted as shown in Figure 6.

The voltage generated when type C sound emitted is higher from other type of sound. In addition, the result also indicated that the PZT inside the speaker give high voltage compare than PZT placed at the speaker face. The voltage generated when the PZT placed in the speaker would be double higher than the PZT placed on the speaker face speaker.

4. Conclusion

The voltage impulse response from PZT was measured for three type of swiftlets sound. The sound was emitted using horn speaker. The sound was dividing into seven frames and it spectrum was plotted using Fast Fourier Transform (FFT) function to acquire the magnitude and frequency information. The comparison voltage generated from PZT showed that there is significant different for three type of sounds. The voltage generated when PZT exposed to the type C sound is higher compare than other type. In addition, the comparison between two locations PZT showed that the high impulse

response is higher when PZT placed in the speaker. The reason can be highlight here is voltage generated by PZT is depending on the power of sound transmitted. The higher power sound transmitted the higher voltage generated from PZT. There are a lot of types of sound pattern used in swiftlets farming industries. However, this research only focused on original swiftlets sound which is having same signal pattern. Therefore, further research is proposed to be conduct in swiftlets house which is exposing to the real field and involve different signal pattern.

5. Acknowledgement

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